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SICK BUILDING SYNDROME:

CAUSES AND EFFECTS

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SICK BUILDING SYNDROME: CAUSES AND EFFECTS

Sick Building Syndrome can be broken down into three sub-categories - Tight Building Syndrome, Humidifier Fever and Legionnaire Disease. TABLE 1.

I will spend most of my time this morning on Tight Building Syndrome.

What is a Tight Building? The definition is arbitrary, practical, and loose. TABLE 2.

There are buildings which meet these criteria in which one can see through gaps between walls and window frames. Paradoxically, some buildings with tight building envelopes - energy efficient residences, for example - do not meet the criteria, since the occupants are able to control the ventilation system.

The health effects that make up Tight Building Syndrome: TABLE 3.

Few researchers would disagree with this list. However, there may be some debate as to whether these are health effects or comfort factors. Is eye irritation an illness? Is headache that clears up on leaving the building an illness? Is fatigue an illness? One can argue either case. The point is not entirely academic, since in real life employees are generally asked to contact health service staff about health problems, and building maintenance staff about comfort problems ...

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today is 21%. My organization no longer measures oxygen levels when investigating office buildings with air quality problems.

TABLE 7.

TABLE 8.

TABLE 9.

Pollutants

Let me review some of the pollutants that may be contributory; and let me say in advance that in practice the search for pollutants is usually - not always - unrewarding. With one notable exception: tobacco smoke. Most investigators and researchers will agree that this is the most important single pollutant in the air of office buildings.

Carbon monoxide

Major indoor sources (unvented gas stoves, heaters, etc.) are not usually a problem in office buildings. Motor vehicle emissions can sometimes enter a building - from an attached parking garage, for example.

CO generated by cigarettes would not usually result in indoor levels exceeding industrial standards, although this can occur in small meeting rooms containing numerous smokers.

Formaldehyde

Measured levels in office buildings infrequently exceed the Canadian residential standard of 0.1 ppm. Formaldehyde is a common component of several types of

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condensation-type synthetic resins (e.g. phenol formaldehyde, melamine-formaldehyde, urea formaldehyde.) Urea formaldehyde resin is used in plywood (adhesive) and particle board (binder). Coated paper, floor coverings and fabrics can contains formaldehyde.

Carbon dioxide

Product of combustion and human metabolism. Outdoor levels typically 320 ppm. Office levels typically 600 ppm, depending on quality of ventilation and density of occupants. CO_2 is measured as a proxy of the quality of ventilation.

Ozone

A power oxidizer, and reactive pollutant. The dominant source is the outdoor air, formed by photochemical reaction. Indoor sources are unusual e.g. electrostatic air cleaners, electric motors, photocopiers.

Ventilation factors as a cause of Tight Building Syndrome

From a previous slide (Slide 5), you will remember that in the experience of NIOSH, in about 50% of the buildings investigated, the problems were attributed to faulty ventilation, temperature, and humidity. Let us look at some standards for temperature and humidity:

These standards may be met for a floor of a building, yet there may still be local problems, created for example by room dividers which restrict airflow.

Temperature and humidity problems are relatively common.

TABLE 10.

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You will also note that most of the listed symptoms are rather vague and subjective, and therefore very difficult to measure in a consistent way. Vague and subjective the symptoms may be, yet the syndrome is striking and convincing, and a time-consuming problem to those of us who have responsibilities in the fields of occupational and environmental health. You will also note that a number of these symptoms are attributable to tobacco smoke, a near universal contaminant of office buildings. Until the last few years, tobacco smoke has been looked upon as a normal inoccuous component of indoor air. I will return to tobacco smoke, and some other contaminants, shortly.

Many organizations in many countries have investigated Tight Building Syndrome. The problem was first described in Scandinavia in the early nineteen seventies. By 1975, it was being frequently described in North America.

An American agency that has conducted large numbers of fairly detailed investigations is NIOSH (the National Institute of Occupational Safety and Health). Health and Welfare Canada experience is similar to that of NIOSH.

TABLE 4.
TABLE 5.

The causes of Tight Building Syndrome

TABLE 6.

First, let me mention a non-cause: lack of oxygen. I can say with confidence that the oxygen level in this building and in virtually every office building in Canada

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LUNG CANCER

This disease is important enough to merit discussion in the context of building associated illness.

When I reviewed some building pollutants, I included radon, asbestos, and secondary cigarette smoke. These agents are all human carcinogens, and can cause lung cancer as well as some other cancers. TABLE 14.

Radon is generally present in much lower levels in office buildings than in residences. Therefore I will not consider it further.

Asbestos is often encountered in building materials, and I would be surprised if this building was an exception. I would also predict that if we were to attempt to measure asbestos in the air of this room it would not be in present in detectable quantities. Asbestos does not present a significant health problem in buildings unless it is damaged, allowing fibres to enter the air.

With regard to secondary tobacco smoke, the evidence from a number of epidemiological studies has been steadily accumulating since 1979. The weight of scientific evidence strongly suggests that secondary tobacco smoke in the workplace is responsible for a significant number of lung cancers - somewhere between 300 and 500 lung cancer deaths per year in Canada.

In conclusion, let me summarize the causes and effects of Sick Building Syndrome: TABLE 15.

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TABLES

SICK BUILDING SYNDROME

1. TIGHT BUILDING SYNDROME

2. HUMIDIFIER FEVER
   (AN INFLUENZA - LIKE ILLNESS)

3. LEGIONNAIRES DISEASE

DEFINITION OF TIGHT BUILDING

LARGE BUILDING

FORCED VENTILATION

OCCUPANTS CANNOT OPEN WINDOWS OR CONTROL OWN VENTILATION

USUALLY NEW OR NEWLY RENOVATED BUILDING

PRESUMED SOURCE OF THE PROBLEM IN 203 INVESTIGATIONS BY NIOSH

	Number	%
Poor Ventilation, Thermal Comfort, or Humidity	107	53
Contaminants from Inside the Building (Copiers, Tobacco Smoke, etc.)	42	21
Contaminants from Outside the Building (Motor Vehicle Exhaust, etc.)	21	10
Building Fabric Contamination (fibreglass, formaldehyde, glues, etc.)	7	3
Biological Contamination	7	3
Miscellaneous or Undetermined	19	10
	203	

MOST FREQUENT OFFENDERS

TOBACCO SMOKE

CARBON MONOXIDE

FORMALDEHYDE

ODORS

VIABLE ORGANISMS?

HEALTH EFFECTS OF TIGHT BUILDING SYNDROME

EYE IRRITATION

HEADACHE

ODOR

SKIN IRRITATION/RASH

SINUS CONGESTION

COUGH

SORE THROAT

SHORTNESS OF BREATH

ABNORMAL TASTE

DIZZINESS

FATIGUE

NAUSEA

WHEEZING AND HYPERSENSITIVITY

CAUSES OF TIGHT BUILDING SYNDROME

1. POLLUTANTS

2. VENTILATION FACTORS:

   - TEMPERATURE
   - HUMIDITY
   - AIRFLOW

3. PSYCHOLOGICAL FACTORS

LEGIONNAIRES DISEASE

You may remember the episode of 1976, at the Bellevue Stratford Hotel in Philadelphia. There were 182 cases of pneumonia-like illness, including 29 deaths, in participants at the annual convention of the American Legion. The diagnosis was elusive. Sabotage, nickel carbonyl poisoning, swine flu, were all suspected, then rejected. Eighteen months later the Centres for Disease Control in the USA isolated and identified Legionella pneumophilia (a bacterium). (The final solution at the Bellevue Stratford hotel was truly final: the hotel was demolished.)

Spread of Legionella in humans: by aerosol from contaminated water systems (e.g. shower heads). Person to person spread has not been described.

How frequent is Legionnaires Disease?

In the USA, in the first four months of 1985, 190 cases were notified. This compares with 102 cases of typhoid, or 982 cases of measles during the same time period.

Other aspects of Legionella are disturbing: TABLE 12.
TABLE 13.

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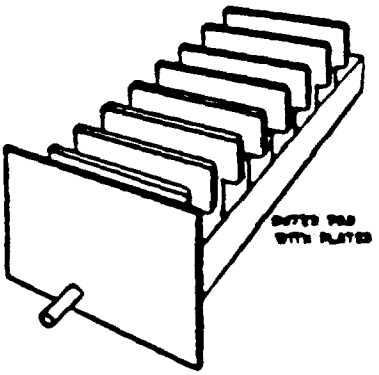
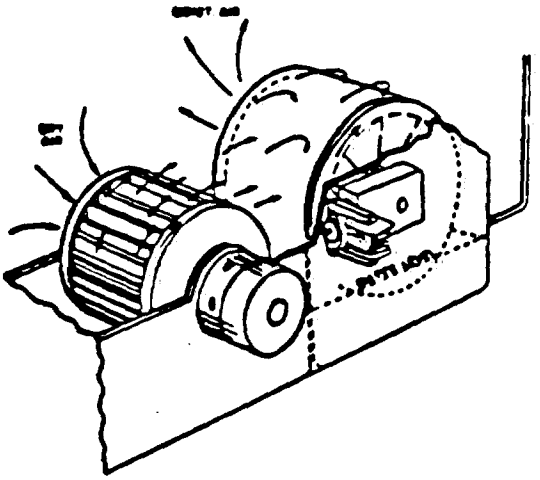
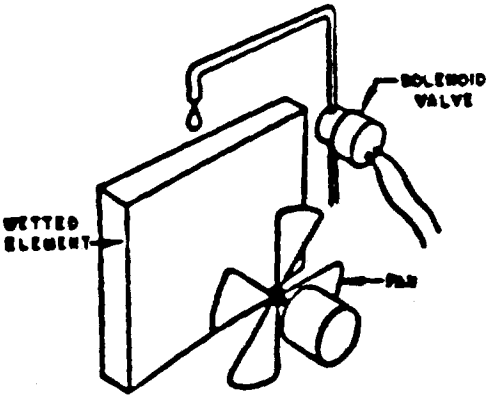
HUMIDIFIERS



Pan-type Humidifier



Wetted Drum-type Humidifier



Power-type Wetted Element Humidifier

INDOOR AIR QUALITY INVESTIGATIONS
MEDICAL SERVICES BRANCH
1984

	Problem Type Found	Building Investigations	
		Number	%
1.	Inadequate Ventilation	64	68
	- poor air circulation		
	- inadequate outdoor air (CO_2 > 800 ppm)		
	- poor temperature/ humidity control		
2.	Outdoor Contaminant	9	10
	- reentry of building exhaust		
	- motor vehicle exhaust		
3.	Indoor Contaminant	5	5
	- copy machines		
	- tobacco smoke		
4.	Building Fabric	2	2
	- blues and adhesives		
	- formaldehyde and organics		
5.	Biological Contaminants	0	0
6.	No problem identified	14	15
	TOTAL:	94	100

Carbon dioxide

Typical outdoor levels: about 330 ppm

Typical indoor levels: about 600 - 1000 ppm

Industrial standard: 5000 ppm

Ozone

Typical outdoor level: 0 - 40 ppb

Typical indoor level: 0 - 20 ppb

Industrial standard: 100 ppb

Viable organisms (bacteria, fungal spores, amoebae, protozoa, nematodes)

No standards

Odors

Standard: acceptability to panel of observers.

Negative ions

No acceptable scientific evidence to suggest that they affect comfort or health.

Photochemical smog

An ingenious hypothesis

LUNG CANCER

~~RADON~~

ASBESTOS

SECONDARY TOBACCO SMOKE

Psychological factors

These can be very important.

The occupant is aware that he is the best sensor in a building - better able to integrate environmental information than thermometers or hygrometers or airflow meters. Yet he does not have the control over the ventilation system that these instruments may have. The only method left open to him is to express his dissatisfaction to the people who have access to the controls. If these complaints do not produce improvement, the occupant feels out of control, and can become increasingly irritated by these conditions and increasingly sensitive to them. We must also bear in mind that ventilation systems are increasingly complex, and that in a large building only the designer may fully understand them. In other words, maintenance staff may not be in full control of the system.

HUMIDIFIER FEVER

Humidifier fever is an allergic illness. The picture is that of a mild flu' like illness - chills, fever, breathlessness, typically on Mondays on returning to work.

Humidifer fever is a type of extrinsic allergic alveolitis - comparable to farmers lung.

The cause: microorganisms in the humidifying system - bacteria, fungi, protozoa and thermophilic actinomycetes. TABLE 11.

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BIBLIOGRAPHY

A QUÉBEC CITY HOSPITAL, 1983

12 CASES OF LEGIONNAIRES DISEASE OCCURRED IN HOSPITAL (NOSOCOMIAL INFECTION)

WATER SAMPLES FROM 38 FAUCETS (IN ROOMS):

30% POSITIVE FOR LEGIONELLA

HOT WATER TANKS:

1 OUT OF 2 POSITIVE

QUÉBEC CITY, 1983

54 DOMESTIC WATER HEATERS WERE EXAMINED

ELECTRIC WATER HEATERS: 11 OUT OF 37 POSITIVE FOR LEGIONELLA

OIL OR GAS WATER HEATERS: 0 OUT OF 17 POSITIVE FOR LEGIONELLA

POLLUTANTS

Carbon monoxide

Typical office levels: 0.5 - 5 ppm

Industrial standard: 35 - 50 ppm

Ambient air standard: 9 ppm

Formaldehyde

UFFI rare in federal office buildings

More important sources:

Carpet backing, fabrics, insulation, particle board;

small amounts from tobacco smoke

Typical office levels: less than 0.1 ppm

Residential standard (Canada): 0.1 ppm

Industrial standard: 1 ppm

Radon

Not a problem in office buildings

Does not give rise to acute symptoms

Asbestos

Not usually a problem unless damaged or disturbed

Does not give rise to acute symptoms

PUBLIC WORKS CANADA STANDARDS

ACCEPTABLE INDOOR TEMPERATURE RANGE	19°C - 26°C
ACCEPTABLE HUMIDITY RANGE	20% - 60%

SICK BUILDING SYNDROME: SUMMARY

EFFECTS

SICK BUILDING SYNDROME ENCOMPASSES: TIGHT BUILDING SYNDROME
HUMIDIFIER FEVER
LEGIONNAIRES DISEASE

CAUSES

POLLUTANTS - CHEMICAL (INCLUDING SOME CARCINOGENS)
- BIOLOGICAL AGENTS

VENTILATION, TEMPERATURE, HUMIDITY PROBLEMS

PSYCHOLOGICAL FACTORS

Walsh, P.J., Dudney, C.S. and Copenhaver, E.D. Indoor Air Quality. CRC Press, Inc., 1984, 1-207.

Woods, J.E. "Ventilation, Health and Energy Consumption: A Status Report." ASHRAE Journal, 1979, 21(7), 23-27.

World Health Organization, Regional Office for Europe, Copenhagen. Indoor Air Pollutants: Exposure and Health Effects. Report on a WHO meeting. EURO Reports and Studies 78. World Health Organization, 1983, 1-42, ISBN 92 890 1244 7.

Yocom, John E. Indoor-Outdoor Air Quality Relationships. A Critical Review, Journal of the Air Pollution Control Association, Copyright 1982, 500-920.

BIBLIOGRAPHY

Ager, B.P., and Tickner, J.A. "The Control of Micro-Biological Hazards Associated with Air-Conditioning and Ventilation Systems." Annals of Occupational Hygiene, 1983, 27, 341-358.

American Conference of Governmental Industrial Hygienists Documentation of the Threshold Limit Values for Substances in the Workroom Air. 4th Edition. Cincinnati: ACGIH, 1980.

American National Standards Institute, and American Society of Heating, Refrigerating and Air-Conditioning Engineers. ANSI/ASHRAE Standard 62-1981. Ventilation for Acceptable Indoor Air Quality. New York: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., 1980.

Arnow, Paul M., et al. "Early detection of Hypersensitivity Pneumonitis in Office Workers." American Journal of Medicine, 1978, 64, 236-242.

ASHRAE Standard. Ventilation for Acceptable Indoor Air Quality. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, ANSI/ ASHRAE 62, 1981, 1-20.

ASHRAE Standard. Thermal Environmental Conditions for Human Occupancy. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, ASHRAE 55, 1981, 1-17.

Cain, W.S. and Leaderer, B.P. "Ventilation Requirements in Occupied Spaces during Smoking and Non-Smoking Occupancy." Environment International, 1982, 8, 505-514.

Canada Diseases Weekly Report. Nosocomial Legionnaires' Disease in the Québec City Area, November 3, 1984, 10-44, 173-174.

Canada Diseases Weekly Report. Legionella and Domestic Hot Water Heaters in the Québec City Area, November 3, 1984, 10-44, 175.

Canada Diseases Weekly Report. Legionella Pneumophila Infections, Scotland, 1983. November 3, 1984, 10-44, 175-176

... /2

"Sick Building Syndrome - The Search for a Cure." Occupational Hazards, 1983, 45, 85-86.

Space Environmental Standards. Preface to the 1979 Edition. Standards and Guidelines Mechanical Design. Public Works Canada, 1979-01-02.

Spengler, J.D. et al. "Indoor Air Pollution: a Public Health Perspective." Science, July 1983, 221, 9-17.

Sterling, E. and Sterling, T. "The Impact of Different Ventilation Levels and Fluorescent Lighting Types on Building Illness: An Experimental Study." Canadian Journal of Public Health, November-December, 1983, 74, 385-392.

Sterling, Theodor D. "Economics and Politics in the Assessment of Causes of Building Illness: the NAS/NRC Report on Indoor Pollutants." International Journal of Health Services, 1984, 14, 43-53.

Stolwijk, Ian A.J. "Tight Building Syndrome." Toxic Substances Journal, Winter 1983/84, 5, 155-161.

Robert, S., Bernstein, A.D., William, G., Sorenson, A. et al. Exposures to Respirable, Airborne Penicillium from a Contaminated Ventilation System: Clinical, Environmental and Epidemiological Aspects. Am. Ind. Hyg. Assoc. J., 1983, 44(3), 161-169

Turiel, I., Hollowell, C.D., Miksch, R.R., Rudy, J.V. and Young R.A. The Effects of Reduced Ventilation on Indoor Air Quality in an Office Building. Atmospheric Environment, 1983, 17, 1, 51-64.

Turiel, I. and Rudy, J. Occupant-Generated CO_2 as an Indicator of Ventilation Rate. Lawrence Berkeley Laboratory, University of California, Energy and Environment Division, LBL-95d, EEB-Vent 80-15, Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48, 1-20.

Walkinshaw, Douglas S. Indoor Air Quality Research in Canada. Prepared for Presentation at the Ener-Health '84 Conference, Winnipeg, Manitoba, October 16-17, 1984, Based on NRC/DBR publication, NRCC 23775. 1-20.

Wallingford, Kenneth M. NIOSH Indoor Air Quality Investigations in Non-Industrial Workplaces: An Update. Cincinnati: National Institute for Occupational Safety and Health, 1984.

... /4

Carlton-Foss, J.A. "The Tight Building Syndrome." ASHRAE Journal, December 1983, 25, 38-41.

Colligan, M.J. "Psychological Effects of Indoor Air Pollution." New York Academy of Medicine. Bulletin, 1981, 57, 1014-1026.

Couch, R.B. "Viruses and Indoor Air Pollution." New York Academy of Medicine. Bulletin, 1981, 57, 907-921.

Huber, G. and Wanner, H.U. Indoor Air Quality and Minimum Ventilation Rate. Environment International, 1983, 9, 153-156.

Int-Hout, D. and Berger, P. (Members ASHRAE) What's Really Wrong with VAV Systems. ASHRAE Journal, December, 1984, 36-38.

McDonald, J. Corbett. Investigation of Employee Health Complaints at Les Terrasses de la Chaudière. Final Report to TB/PSAC Steering Committee, Treasury Board of Canada Contract TB/CT-REQ B8059, July 1984, 1-41.

McGregor, R.G., Vasudev, P., Létourneau, E.G., McCullough, R.S., Prantl, F.A. and Taniguchi, H. Background Concentrations of Radon and Radon Daughters in Canadian Homes. Health Physics, August, 1980, 39, 285-289.

Moghissi, A.A., Moghissi, B.D. Environment International. A Journal of Science, Technology, Health, Monitoring and Policy. Pergamon Press, 1982, 8, (1-6), 1-534.

Moschandreas, D. "Indoor Air Quality Relationship - A Critical Review." Journal of the Air Pollution Control Association, September 1982, 32, 904-907.

National Academy of Sciences Committee on Indoor Pollutants. Indoor Pollutants. National Academy Press, Washington, D.C., 1981.

National Primary and Secondary Ambient Air Quality Standards. Environmental Protection Agency. Federal Register, Thursday, February 8, 1979, 44, 28, 8202-8221.

Photochemical Oxidants; Measurement of Ozone in the Atmosphere; Requirements for Preparation, Adoption, and Submittal of Implementation Plans. Environmental Protection Agency. Federal Register, Thursday, June 2, 1978, 43, 121, 26972-26981

Proceedings of the 3rd International Conference on Indoor Air Quality and Climate. Held in Stockholm, August 20-24, 1984, 23-29.

... /3